



# A comparative analysis of ecosystem services valuation approaches for application at the local scale and in data scarce regions



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## ABSTRACT

Despite significant advances in the development of the ecosystem services concept across the science and policy arenas, the valuation of ecosystem services to guide sustainable development remains challenging, especially at a local scale and in data scarce regions. In this paper, we review and compare major past and current valuation approaches and discuss their key strengths and weaknesses for guiding policy decisions. To deal with the complexity of methods used in different valuation approaches, our review uses multiple entry points: data *vs* simulation, habitat *vs* system *vs* place-based, specific *vs* entire portfolio, local *vs* regional scale, and monetary *vs* non-monetary. We find that although most valuation approaches are useful to explain ecosystem services at a macro/system level, an application of locally relevant valuation approaches, which allows for a more integrated valuation relevant to decision making is still hindered by data-scarcity. The advent of spatially explicit policy support systems shows particular promise to make the best use of available data and simulations. Data collection remains crucial for the local scale and in data scarce regions. Leveraging citizen science-based data and knowledge co-generation may support the integrated valuation, while at the same time making the valuation process more inclusive, replicable and policy-oriented.

## 1. Introduction

The definition and classification of Ecosystem Services is still debated (see *e.g.*, Daily, 1997; de Groot et al., 2002; Millennium Ecosystem Assessment (MA), 2005; Kremen, 2005; Boyd and Banzhaf, 2007; Wallace, 2008; Fisher et al., 2009; TEEB, 2010). But over the last decade and a half, the concept has gained considerable attraction across science and policy arenas, especially on how the ecosystem services can be defined, valued and integrated into conservation and sustainable development agendas (Daily et al., 2009; de Groot et al., 2010 and Laurans et al., 2013). In this paper, we define integrated valuation of ecosystem services at the local scale as the detailed understanding of how ecosystem services provide benefits to human wellbeing, their quantitative measurements (including spatial mapping and modelling), trade-offs analysis and the use of knowledge in planning and decision making.

The value of ecosystem services is now widely acknowledged for their positive role in economic, environmental and social well-being - the three main pillars of sustainable development (UN, 2002;

UNDESA, 2015). As such, the concept is becoming a major driving force for natural resources management and human wellbeing (see, TEEB, 2010; Diaz et al., 2015). It has been linked to policy and decision making as an innovative strategy for the improved management of land, water and living resources that can promote conservation and at the same time fostering human well-being (Tallis et al., 2008; Daily et al., 2009; Haines-Young and Potschin, 2010). However, the operationalization of the concept has often remained elusive, especially for an integrated valuation of available services at local and in data scarce regions. Scientific advances related to ecosystem services production functions, services flow and trade-offs among multiple ecosystem services are increasingly important for the practical implementation of the concept into conservation and sustainable development projects (Tallis et al., 2008, Daily et al., 2009 and Ash et al., 2010).

The valuation of ecosystem services (both quantitative and qualitative) and their integration into policy and decision making practices has been a matter of debate ever since the concept first emerged in the early 1990s (Daily, 1997; de Groot et al., 2002; Brauman et al., 2007; Daily et al., 2009, de Groot et al., 2010; Guerry et al., 2015). An

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appropriate analytical framework is required to bridge natural science, economics, conservation and development, and public and private policies (Braat and de Groot, 2012). The integration of different valuation approaches, especially quantitative measurements of services production, distribution and consumption, should be closely aligned with social and economic valuation approaches. Successful operationalization of the concept may need integration of appropriate valuation techniques relevant to policy and decision making practices.

In this paper, we present a review of key ecosystem services frameworks combined with a comparative analysis of selected peer-reviewed and grey literature to explore how different valuation approaches have been used to improve policy and decision making. The selection of ecosystem services valuation approaches is based on their applications for improving our understanding of services through quantitative and qualitative assessments. We discuss on how they can contribute to an integrated valuation of ecosystem services at local and data scarce regions. Subsequently, we assess selected spatially explicit policy support systems by analysing their capabilities to support integrated valuation. The selection of six policy support systems is based on their direct and/or potential roles in different valuation approaches (see in Section 4). As the paper aims to identify appropriate valuation approaches for the local and data scarce environments, we concentrate on the main gaps and how they can be addressed and making the valuation practices more inclusive and policy relevant.

First, we focus on how the natural capital and ecosystem services frameworks have been evolved over the recent years as a major alternative approach to enhance conservation activities and sustainable development. Next, we present a comparative analysis of different valuation approaches along different axes of variability: data *vs* simulation, habitat *vs* system *vs* place-based, specific *vs* entire portfolio, local *vs* regional, and monetary *vs* non-monetary (including cultural and aesthetic) valuation approaches. Then, we discuss different spatial-based policy support systems as a platform for combining more than one of these approaches and compare the strengths and weaknesses of their application at a local scale and in data scarce regions. Lastly, we discuss major challenges in the use of different valuation approaches and highlight the need for an integrated approach with the application of locally relevant data and knowledge co-generation practice to make the ecosystem services valuation more effective in policy and decision making.

## 2. Evolution of ecosystem services frameworks and persistent challenges for local level integrated valuation

Soon after the emergence of the ecosystem services concept as a way to redefine the role of ecosystem services in conservation and sustainable development, different frameworks have emerged to systematize this new knowledge and to guide policy and decision making practices. The Millennium Ecosystem Assessment (MA) was the first major international effort to explore the linkages between ecosystem services and human well-being. The MA framework was designed to understand the current state of major ecosystem services, trends in their production and flows, as well as major pressures and threats, management decisions and policy formulations (MA, 2005). The concept has been widely accepted among scientific and policy communities, and as a result of this, new approaches have been developed to value the services and thus better integration of the concept in research, conservation and development sectors (Daily and Matson, 2008). However, some policies and practices in water and land resources management that intended to improve ecosystem services and human well-being are based on untested assumptions and sparse information (Carpenter et al., 2009; Yang et al., 2013). This is particularly the case at local scale and where data are scarce. A concrete step towards local scale integrated valuation is clearly needed to improve the knowledge of ecosystem services and their integration into decision making.

Since the MA, different alternative frameworks have been developed to make the ecosystem services concept more relevant to policy and decision making processes. In response to the lack of economic perspective of biodiversity loss and ecosystem degradation in the MA framework, The Economics of Ecosystems and Biodiversity (TEEB) came into effect emphasizing more on joint efforts of ecologists and economists in ecosystem services valuation (TEEB, 2010). It has been strongly argued that any ecosystem services valuation should begin with the detailed understanding of biophysical generation of services to provide solid ecological underpinning to the economic valuation (de Groot et al., 2010). It is important to combine both ecological and economic perspectives in a collaborative way, so any trade-offs reflected at individual and societal choices are better understood at policy and decision making levels (Polasky and Segerson, 2009). Such linkages have been highlighted in the TEEB framework for mainstreaming the valuation of ecosystem services into local, national and international planning processes (TEEB, 2011 and 2012). The framework also intends to inform conventional economic policy about its impact on ecosystem health and biodiversity. It also makes a distinction between services and benefits and explicitly acknowledges that services can benefit people in multiple and indirect ways (TEEB, 2010). Although the framework looks at conservation and sustainable development through a strongly economic lens, the integration of the framework into policy and decision making mechanisms has been slow. Often the strong lack of locally relevant data is the main bottleneck for a successful integration of framework into policy and decision making processes.

To strengthen further the role of biodiversity and ecosystem services in human wellbeing and to promote sustainable development, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) came into effect with comprehensive interlinkages among diverse scientific disciplines, stakeholder interests and knowledge systems (Diaz et al., 2015). The framework focuses on co-construction of integrative knowledge which could be useful for wider research and knowledge-policy communities including the valuation of ecosystem services. The framework also focuses on the central role that institutions, governance and decision-making can play towards the better realization of nature's services in improving human welfare. It links multiple knowledge systems to ensure nature conservation and sustainable use of biodiversity for greater benefit to humanity. Although the IPBES framework is very useful to characterize the role of nature's benefits in enhancing human wellbeing, the framework is primarily focused at regional and international scales. There is no clear recognition of integrated valuation of services at local scale which could eventually create a functioning science-policy interface for higher level. In addition, the framework has an exclusive focus on living resources such as biodiversity and ecological functioning and how that produces ecosystem goods and services to people. Not incorporating non-living natural capitals such as water, soil and minerals resources could eventually make the framework less relevant to policy and decision making. The framework, while concentrating on ecological functioning of biodiversity and ecosystem services, does not explicitly recognize the crucial role of non-living resources in human wellbeing. Without proper consideration of these different elements of natural capital and ecosystem services, the framework could rather be reduced to an effort to understand ecological functioning and nature's intrinsic values but may not support the integrated valuation of services to influence decision making.

In conclusion, the reviewed ecosystem services frameworks are useful to increase the understanding of natural capital and ecosystem services, their stocks & flows and linkages (direct and indirect) between them and human well-being. Some frameworks have also raised the need for integrated valuation of services relevant to policy and decision making. However, they are too focused on assessing ecosystem services at regional and global significance of ecosystem services. At the local scale, the dynamic nature of ecosystems and

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